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EVALUATING THE PERFORMANCE OF DUAL DISK RIDGE

Hussein Abbas Jebur[1]* and Majed Salih Himoud[2]

[1]Department of Agricultural Machines and Equipment, College of Agriculture, University of Baghdad, Iraq.
[2]Department of Agricultural Machines and Equipment, College of Agriculture, University of Basrah, Iraq.

Abstract

The present research was carried out to evaluate some operating parameters affecting the performance of dual disk ridge, in a silty clay soil with moisture content of (14%). The tractor "CASE JX75T" and dual disk ridge were used machinery units. Some parameters of study encompass three levels tractor forward speeds g1, g2 and g3 and two tilt disc angles (30^0 - 45^0), by using randomized complete block design (RCBD) with a split plots. A few technical performance indicators for machinery units were studied which include; specific fuel consumption (S.fC), soil disturbed volume ($S._{v.d}$), specific resistance, pull force and wheel slip. The experimental results reveal that the forward speeds 2.44 km/h was superior among other tilt disc angles in recording lower rate both of the specific resistance 18.32 kN/m^2, travel reduction 2.70% and higher rate of (S.fC) 0.743 l/kW.h, while the speed 4.33 km/h was recording higher (S.v.d) 449.71 m^3/h. The angles of 45^0 was superior in recording higher rate of the ($S._{v.d}$) 395.96 m^3/h and (S.fC) 0.798 l/kW.h with lower rate of specific resistance 20.66kN/m^2. The angle of 30^0 was superior in recording lower rate of the travel reduction value 3.39% and pull force 4.79 kN. As the interaction between tilt disc angle and forward speed, it was significant for all parameters whereas the third forward speed of 4.33 km/h with the tilt disc angle (45^0) was superior in recording higher rate of the ($S._{v.d}$) 514.67 m^3/h, (S.fC) 0.798 l/kW.h and lower rate of specific resistance 26.35 kN/m^2.

Key words : Ridge, soil disturbed volume, tilt disc angles, tractor.

Introduction

In most developed countries, agriculture industry has become the main source because of its national income and it has become impossible to increase agricultural production whether by horizontal expansion through the reclamation of new land not cultivable or by vertical expansion using modern methods. Experiments have shown that agriculture mechanization especially if used with advanced technology, this will lead to a significant increase in the rate of production per hectare, which made agricultural officials attach special importance of the agriculture mechanization with economic manner in the circumstances, Especially in reclaimed lands where the large areas with few manpower. Antwerpen *et al*. (1991) explained that it should be kept the ridge on its height, shape and stability and also mentioned that the best height of the ridge between (20-30) cm and it is important to reform the ridge every year. Bukhari *et al*. (1992) found that best stability of ridge was at tilt disc angle 42^0, as it gave the highest value of the stability of the ridge, which amounted to 93.99%, while angle 17^0 gave a stability ratio of 72.45%. Abdalla *et al*. (2014) also found in his study the overlap between the front speed of the tractor and the angle of the disc, As the increase in the front speed from 1.31 to 2.45 led to a significant increase in the pull force and qualitative resistance significantly by (6.41% and 17.27%) respectively at 45°, due to the increase of the cutting area when increasing the angle, which led to increase the pull force and qualitative resistance. Al-Hashimy (2012) explained that increasing the angle of the disk led to lower requirements for the capacity of the disk plow also confirmed that the ridge was the best in recording the lowest rate of slippage and fuel consumption. In a study carried out by Bernik and Vucajink (2008) used three types of ridge attached cultivation in the silty clay (disc ridge driven by the PTO in the jars and a discrete rotary blade due to its contact with the soil and the slate ridge) and effect of this on the

**Author for correspondence*

Fig. 1 : shows the connection of the dual disk ridge with the tractor.

drawbar pull, drawbar power actual productivity, the specific energy and the stability of the ridge after 50 days of treatment and penetrating the soil at a depth of 15 cm from the surface of the ridge. The results showed that the disc ridge driven by the PTO shift was superior to the other two species, with lowest drawbar pull 8.06 kN, drawbar power 4.03 kW and the highest 3.7 ha/h. In a study by Dahab *et al*. (2007) using both the chisel plow, disk ridge and assembly both of chisel plow and disk ridge in heavy clay soils and their effect on pull force, slippage ratio, and fuel consumption, the disk ridge superiority significantly exceeded the rest of the coefficients in all studied traits. Sessiz *et al*. (2008) reported that the slate ridge recorded a lower fuel consumption of 1.85 l/ha compared to the moldboard plow that recorded the largest consumption of fuel 13.38 l/ha when studying several systems for soil preparation in clay soil. Nalavade (2010) shows that increasing the disk angle in soil preparation equipment, which is rotated with soil or managed by the PTO, increases the size of the soil that is in contact with the disc during rotation. The general objective of this study was to test and evaluate the effect tilt disc angles and forward speed on some tractor performance parameter, namely; specific fuel consumption, soil disturbed volume, specific resistance, pull force and wheel slip.

Materials and Methods

Field experiments

The experiments were carried out on farm of the Agriculture College, University of Basrah, in a silty clay soil with moisture content of 14% at different conditions parameters using two tilt disc angle (30^0 - 45^0), three levels tractor forward speeds from 2.44 km/h to 4.33 km/h by using randomized complete block design (RCBD) with a split plots.

Materials experiment

Tractors

Two tractors from the same Model (CASE JX75T) were used as shown in table 1.

Dual disk ridge

The dual ridge is formed as shown in fig. 1 of two discs 65 cm diameter. It is easy to change the horizontal distance and change the tilt angle of the disc, resulting of formation a ridges in different dimensions and shapes as shown in table 2.

Load cell

A load cell (cylindrical S. Beam. Type, L.SB600 Model and 111.2 kN Capacities) is considered as an imitative and empirical technique for measuring the tractive force in this study. The load cell system is illustrated in fig. 2. It consists of :

1. Load cell
2. Computer
3. Data wire
4. Points for fixing system in tractor source and load source
5. Program for recording and save data on computer.

Fuel consumption System

Measurement and calculation of fuel consumption for tractor engine was performed, on the basis of volume under different operation by using diesel fuel .the system depends on the measurement of a given volume of fuel

Table 1 : The specifications of the used tractors.

Tractor model	**CASE JX75T**
Engine	IVECO series 8000
Fuel	Diesel
The system of fuel combustion	Pressure
No. of Engine Cylinders	4 cylinders
Engine Displacement (Capacity)	3908 cm^3
Engine Power	55kW/75hp
Engine Max. torque	242Nm@1500rpm
Thrust type	4WD
Tractor weight	2575kg
Tire size	Front: (11.2-24) Rear: (16.9-30)
Made in	Italy - 2013

Table 2 : The specifications of dual disk ridge.

Disk type	Edge smooth, sharp
Number of disc	2
Working Width (cm)	60-120 Regulated
Weight (kg)	175
Frame width of ridge (cm)	100
Height of the frame (cm)	110
Disc diameter (cm)	65
Power requirement (HP)	30 – 50
Depth who works with him ridge (cm)	0 - 20
Tiltdisc angle	15 - 45

consumed in the operation of the engine during certain period of time where, it is determined by using stopwatch. The device shown in fig. 3 consists of 1. fuel tank 2. fuel valve. 3. graduated cylinder 4. valve 5. fuel filter 6. helpful fuel pump 7. feeding 8. injections pump 9. tube of excess from main fuel pump 10. tube of excess from injection 11. main plastic tube.

Calculation of parameters

Methods of work

Theoretical speed for tractor CASE JX75T was calculated by measuring the time required to distance 20 m on the straight asphalt street after 1500 rpm to stabilize engine speed and the operation was repeated three times of each forward speed using g1, g2 and g3. Calculate the theoretical speed by using the following equation :

$$Ts = D / t \times 3.6 \quad (1)$$

Where,

Ts = theoretical speed (km/h)

D = travelled distance

t = the spent time in the distance (sec).

The actual forward speed (As) for tractor CASE JX75T was measuring in the field. Where used with pull of the tractor and dual disk ridge. The engine speed for tractor was stabilize on 1500 rpm, also, all the working tilt disc angle and forward speed were stabilized. In addition, the time was measured for distance 20 m and repeated the operation three times for all working tilt angle of the disc and all the forward speed.

Pull force

The pull force has been measured at the same time as the measurement of actual forward speed using the load cell. A load cell (cylindrical S. Beam. Type, L. SB600 Model and 111.2 kN Capacities) is considered as an imitative and empirical technique for measuring the draft force, fig. 2 was attached with a horizontal chain between two tractors to measure the draft force. Tractor CASE JX75T was used as a rear (towed) on which the dual disk ridge was mounted; whereas the front tractor CASE JX75T was used to pull the towed tractor with the attached dual disk ridge through the load cell dynamometer. The towed tractor was working on the neutral gear while the implement was in the operating position; the draft force was recorded and saved on the portable computer. On the same field the implement was lifted out of the ground and the rear tractor was pulled to record the rolling resistance (A), then the drawbar pull (B) was calculated as follow :

$$NDp = B - A \quad (2)$$

Drawbar power

P_{db} = NT ´As/3.6 … (3) (Jebur, 2018)

Where,

P_{db} = is drawbar power (kW)

NT = is net traction (kN)

As = actual speed (km/h)

Fuel consumption (fC)

Fuel consumption was calculated as follows :

$$fC = \left(\frac{V}{t}\right) \times 3.6 \text{ (Macmillan, 2002)} \quad (4)$$

fC : rate of fuel consumption (l/h)

V : volume of consumed fuel (cm^3)

T : time (sec)

The slippage (travel reduction)

The travel reduction of tractor was calculated according to the equation:

S = (Ts - As) / Ts × 100 (Younis and El. Said, 2009) (5)

Where,

S = slipping (%)

Ts = theoretical speed (km/h)

As = actual speed (km/h)

Soil disturbed volume ($S._{v.d}$)

The soil disturbed volume was calculated assuming that the area of the ridge was rectangular. Soil disturbed volume is the amount of soil that is raised by the machine during the time unit

$S._{v.d}$ = [width of ridge (m) × Height of ridge (m) × forward speed (m/h)]/2 (6)

Specific resistance

The specific resistance was measured by using the following formula :

SR = F/A (7)

Where,

SR = specific resistance (kN/m^2)

F = drawbar pull (kN)

A = Area of disturbed (m^2)

Specific fuel consumption (S.fC)

$$S.fC = \frac{fC\left(L.h^{-1}\right)}{p_{dp}\left(kW\right)} \text{ (Jebur, 2016)} \quad (8)$$

Where,

S.fC = specific fuel consumption (l/kW.h)

P_{dp} = drawbar power (kW)

fC = fuel consumption ($L.h^{-1}$)

Results and Discussion

The percentage of slippage

Results illustrated in fig. 4, showed the significant effect of traveling speeds and tilt disc angle on the travel reduction. It's clear that the wheel slip increased from 3.2% to 5.10% by increasing the forward speed from 2.44 km/h to 4.33 km/h at tilt disc angle 45^0, while at 30^0 tilt disc angle the wheel slip recorded lowest value 2.3% to 4.10% than 45^0 at the same forward speed. These maybe. The increase of tilt disc angle increases wheel slippage percentage. Abu-Hamdeh and Reeder (2003) stated that the reason of increasing slippage may be due to increase drawbar pull because of increasing working width of disc.

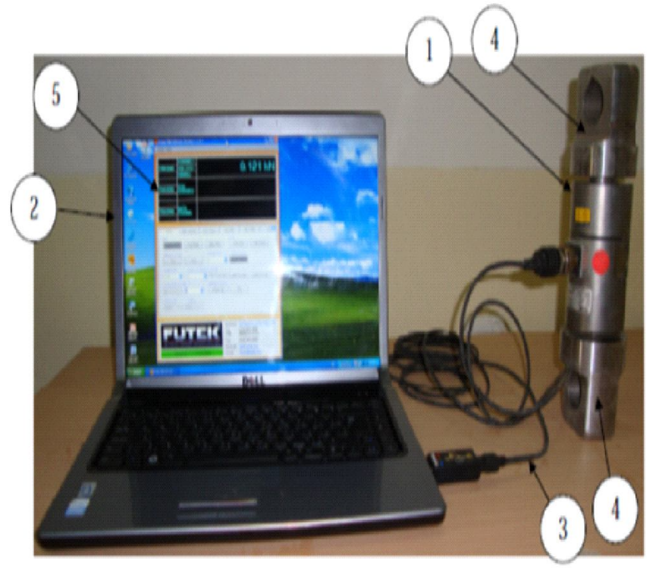

Fig. 2 : Load cell system.

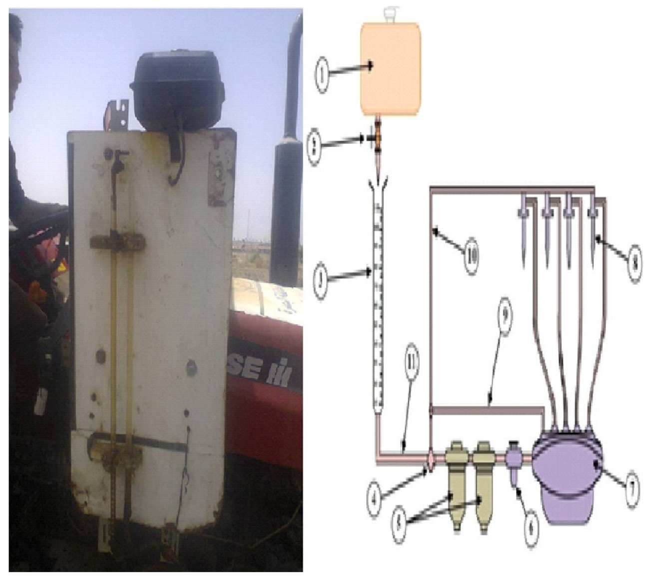

Fig. 3 : Fuel consumption system.

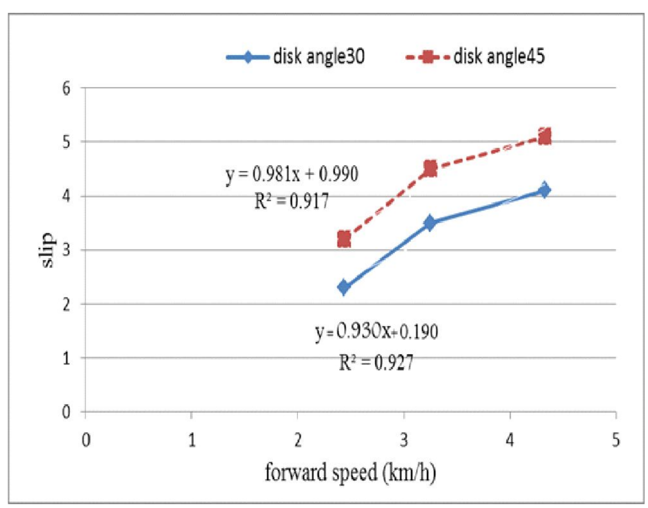

Fig. 4 : Effect of tilt disc angle and forward speed on slip.

Table 3 : Effect of the tilt disc angle and speed on specific fuel consumption (l/kW.h).

Specific fuel Consumption (l/kW.h)			
Speed km/h	Tilt discangle		Average speed
	30	45	
G1	0.645	0.833	0.743
G2	0.633	0.792	0.712
G3	0.602	0.770	0.686
L.S.D = 0.05	0.0123±0.001		0.0041±0.0003
Average tilt discangle	0.626	0.798	
L.S.D = 0.05	0.012±0.002		

Pull force

Fig. 5 shows the significant effect of tilt disc angle at different forward speeds on pull force. It's clear that the pull force increased from 4.3kN to 6.7kN at tilt disc angle 45^0 by increasing forward speed from 2.44 km/h to 4.33 km/h, while at 30^0 tilt disc angle the pull force recorded lowest value 3.6 kN to 5.90 kN at the same forward speed. These may be due to increase the area of the raised soil section by increasing the tilt disc angle and yielding greater depth and width of the pieces. These results are consistent with the results obtained by Yousif and Said (2009), who found that increasing tilt angle of disc led to an increase in the width of cut.

Specific resistance

Fig. 6 shows that the effect of overlap between the tilt disc angle and the front speed has a significant effect on specific resistance. As seen from the fig., the use of 45^0 tilt disc angle at forward speed 4.33 km/h superposed to all other speeds, in recording lower specific resistance 26.35 kN/m^2, while the use of 30^0 tilt disc angle recording higher specific resistance 29.80 kN/m2 at same front speeds. These may be due to increase the drawbar pull by increasing the forward speed. These results approves with the result obtained by Abu-Hamdeh and Reeder (2003), who founded that a decrease in the tilt angle resulted in an increase in implement penetration.

Soil volume distribution

Fig. 7 shows the relationship between tilt disc angle and forward velocity and its effect on soil disturbed volume. The tilt angles 45^0 superposed the 30^0 at the forward speed of 4.33 km/h, in recording higher soil disturbed volume 514.67 m3/h. These may be due to increase the rate of soil cut. Abdalla *et al*. (2014) and Abdalla (2008) found that the increase of tilt angle led to an increase in the rate of soil cut, which led to an increase in the quantity

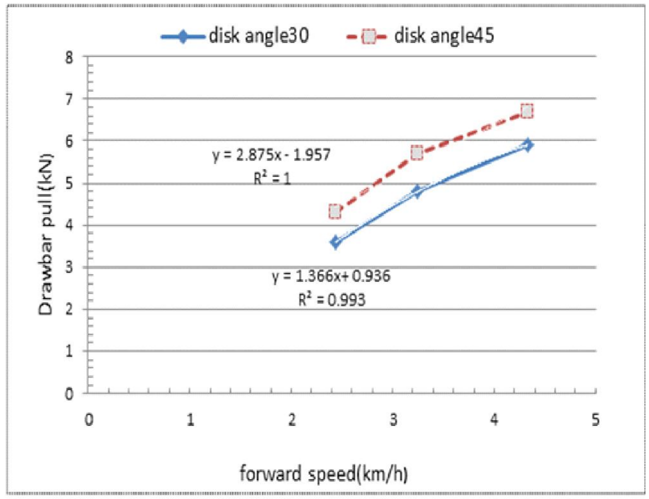

Fig. 5 : Effect of tilt disc angle and forward speed on drawbar pull.

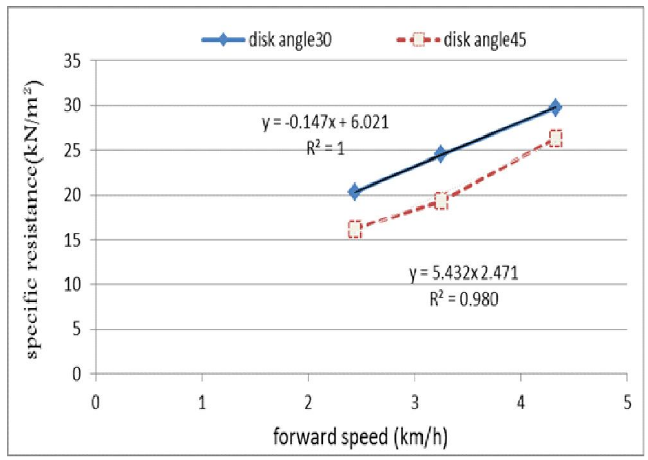

Fig. 6 : Effect of tilt disc angle and forward speed on specific resistance.

of cut soil thus increasing the soil disturbed volume.

Specific fuel consumption

Results illustrated in table 3 shows the effect of tilt disc angle and forward speed and their overlaps on the specific fuel consumption. The table shows that when the speed increasing from G1 to G2 and then G3 the specific fuel consumption decreased from 0.743 to 0.712 then to 0.686 l/kW.h, respectively. The reason may that increasing practical speed leads to increase the pull and fuel consumption. These results are consistent with the ones obtained by Jebur *et al*. (2016). The same table shows that increasing tilt disc angle from 30^0 to 45^0 the specific fuel consumption has increased from 0.626 l/kW.h to 0.798 l/kW.h, respectively. This may be due to increased area raised of the dual disk ridge. These results are consistent with the ones obtained by Osman *et al*. (2011) and Abdalla *et al*. (2017). The interaction between tilt disc angle and forward speed was significant on the

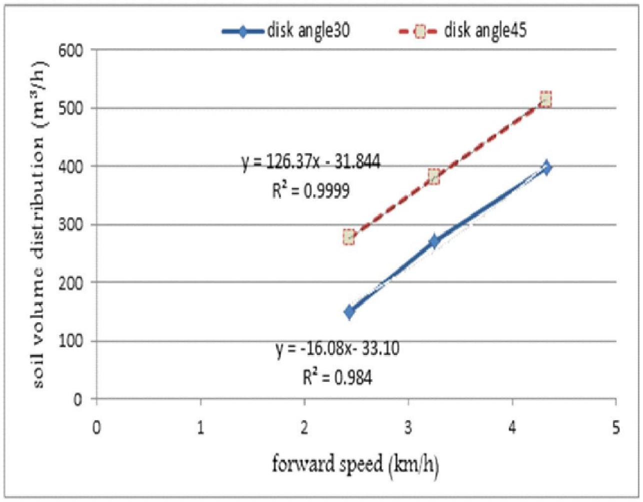

Fig. 7 : Effect of tilt disc angle and forward speed on soil volume distribution.

specific fuel consumption. Interaction of the tilt disc angle (45^0) with the forward speed (G1) gave higher specific fuel consumption amounting to 0.833 l/kW.h, while the overlap of the tilt disc angle (30^0) with the forward speed (G3) gave lower specific fuel consumption amounting to 0.602 l/kW.h.

Conclusion

From the study conducted, the following were concluded :

Increasing the tilt disc angle for dual disk ridge and forward speed resulted in an Increase in pull force, percentage of slippage and soil disturbed volume. The tilt angle of 45^0 is the most opportune for dual disk ridge as it recorded the highest specific fuel consumption; soil disturbed volume, low specific resistance, recorded temperate value of the pull force and wheel slippage. The overlap between the tilt disc angle and forward speed a very significant effect on all attributes, which studied.

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